

SCOPE OF WORK
SLUDGE CONDITIONING CAPACITY INCREASE PROJECT
BY
FLSMIDTH
JULY 15, 2010

HIGH PRIORITY

- Goal:
 - FLSmidth to recommend plant modifications needed to separate the solids from the water in Units 1 and 2 scrubber sludge based upon quantities, particle size distributions, and constituents provided by IPSC.
 - FLSmidth will supply a capital cost estimate for equipment, demolition, installation, structural modifications, and engineering within the limits of plus 100% and minus 50% by July 30, 2010.
 - FLSmidth will provide additional services to refine this estimate after July 30, 2010 per instructions from IPSC, with total cost for the entire project not to exceed the original Purchase Order amount.
- Project Boundary Limits
 - Scrubber Sump Pumps in Units 1 and 2 are a boundary
 - Loading Zones of conveyors leaving Sludge Conditioning are a boundary
 - The chutes below the Ash Silo Rotary Vane valves are a boundary
 - Thickener overflow lines are a boundary
 - Polymer feed system insertion points are a boundary
 - Power and utility feeds to the area are boundaries.
- Major Equipment Included in Scope Evaluation
 - Hydrocyclone feed pumps
 - Hydrocyclones
 - Thickeners
 - Thickener Underflow Pumps
 - Vacuum Filters and their auxiliary equipment
 - Filter Feed Pumps
 - Filter discharge conveyors
 - Pug Mills
 - Piping between equipment
 - Electrical Substation
 - Electrical Motor Control Centers
- Process Scope
 - Process Flow Sketch
 - Estimate of Flows
 - Equipment type & size recommendations
- Mechanical Scope
 - Equipment List with pricing
 - Hand mark-ups of existing GA's
 - Piping material take-off & cost estimate

- Demolition & Construction Estimate
- Structural Scope
 - Hand mark-up of existing GA's
 - Material Take-off
 - Demolition & Construction Estimate
- Electrical Scope
 - Cursory evaluation of electrical capacity available for changes in system
 - Cost Estimate: Capital, demolition and installation
- Constraints
 - Eliminate solids overflowing the thickeners under normal operating and weather conditions
 - Eliminate bypassing of sludge directly to the waste water holding pond
 - Remove solids from water and send to existing discharge conveyors
 - No modifications to existing ash silos and rotary vane valves
 - Limit filter operation to 7 hours if practical
 - Change cyclone operation from on/off to variable flow.

LOW PRIORITY

After completion of work scope listed above, provide assistance with items below per IPSC direction.

- Recommend Scrubber Sump Pump Type
- Recommend piping from scrubber to Sludge Transfer and from Thickener underflow to filter feed tank
 - Rubber Lined steel
 - HDPE
 - Abrasion resistant FRP
 - Other
- Evaluate Thickener feed splitter to divide flows equally
- Evaluate flocculant feed to thickeners for better control
- Evaluate removal of dirt around sides of thickeners
 - Provide structural modifications if required
- Recommend corrosion prevention measures/materials for thickeners
- Recommend ways to eliminate thickener upsets
- Recommend better dirt/water seal for thickener rake drives
- Evaluate IPSC desire to dump thickener sump pump discharge into thickener overflow launders instead of the feed wells.
- Consider building a common header for vacuum pump line to vacuum filters
- Change Cyclone Apex section bolts to quick release clips for easier cleaning
- Recommend Cyclone shut-off valves that don't leak and extended life.
- Recommend Cyclone crane for wet area (existing rusted beyond use)
- Right-size Vacuum Filter discharge blowers
- Recommend better Vacuum Filter cloth
- Recommend Pug Mill discharge chute material & geometry changes

IPSC - MATERIAL BALANCE CALCULATIONS - SLUDGE CONDITIONING CAPACITY INCREASE PROJECT, JULY 2010

Design Basis/Assumptions

800	t/hr Coal combined for two generating units
1.1	% Design sulfur in the coal
0.95	Fraction SO ₂ removed
0.95	Fraction oxidation of absorbed SO ₂ for combined scrubber effluent
100	% load on both boilers for maximum solids production rate
17	% suspended solids in scrubber effluent to dewatering
0	ash solids in scrubber solids
5	% of limestone remains unreacted in filter cake (inerts plus unreacted CaCO ₃)
1.030	liquid specific gravity (from IPP operations data, given to FLSmith during 7/14/10 plant visit)
2.32	solids specific gravity (from Krebs data sheet for hydrocyclone project)
1.138	slurry specific gravity

Please check assumptions highlighted in yellow
Potential Problem

1.032 Weighted

Calculations

16.72 tons/hr SO₂ removal
 42.7 t/hr gypsum produced
 1.6 t/hr calcium sulfite produced
 1.3 t/hr limestone solids in solids from scrubbers
 45.6 t/hr total solids from scrubbers to dewatering

1	Slurry from Scrubbers to Hydroclone Feed Tank	Design
	Flow Rate From Scrubbers to Hydroclone Feed Tank, gpm	941.7
	Solids Rate to hydroclone feed tank, lb/hr	91,124
	Solids Rate to hydroclone feed tank, ton/hr	45.6
	Percent solids in slurry to hydroclone feed tank, %	17
1	Slurry to Hydroclones	
	Flow rate to hydroclones, gpm	941.7
	Percent solids in hydroclone feed, %	17
2	Slurry in Hydroclone Overflow To Thickener	
	Flow rate in hydroclone overflow, gpm	780.4
	Percent solids in hydroclone overflow, %	4.8 From Krebs Cyclone Calculations July 9, 2007
	Solids rate in hydroclone overflow, lb/hr	23,506 From Krebs Cyclone Calculations July 9, 2007
	Solids rate in hydroclone overflow, ton/hr	11.8
3	Slurry in Hydroclone Underflow to Filter Feed Tank	
	Flow rate in hydroclone underflow, gpm	161.3
	Percent solids in hydroclone underflow, %	56 From Krebs Cyclone Calculations July 9, 2007
	Underflow slurry specific gravity	1.496
	Solids rate in hydroclone underflow, lb/hr	67,618
	Solids rate in hydroclone underflow, ton/hr	33.8
	Total mass flow rate, lb/hr	120,747
	Hydroclone Underflow Tank to Filters @ 12 hr/day Filter Operation	
	Flow rate, gpm	576
	Percent solids, %	46
	Solids rate, lb/hr	182,248
	Solids rate, ton/hr	91.1
	Hydroclone U'flow Inventory surge during 12-hr/day filter downtime	207,349
	Hydroclone tank capacities at 15-ft height differential, gal	107,894
	Minimum Hours/day of filter operation required, hours/day	23.1
	Vacuum Filter Operation Calculations - 12-ft dia by 18-ft filter = 678 sq.ft.	
	Req'd filtration rate for 12-hr/day operation, lb/hr/ft ²	269
	Filter Cake Moisture content Estimate at filtration rate, wt %	17
	Wet Cake production rate, ton/hr	110
	Water in cake, gpm	72
	Filtrate, gpm	504
	Fines Thickener Operating Calculations - Using one 60-ft. diameter thickener	
	Calculated Thickener Unit Area, ft ² /d	10.0
	Design (operating) underflow concentration with polymer, wt.% ss	30
	Estimated Maximum pumpable solids conc., wt.% ss	45
	Minimum operating underflow conc., wt.% ss	15
	Underflow slurry specific gravity	1.236
4	Continuous underflow pumping rate at design U'flow conc., gpm	127
	Underflow total mass flow rate, lb/hr	78,352
	Overflow rate at design underflow concentrations, gpm	653.7
	Hours sludge storage in thickener bed/ ft. of sludge at design, hours	2.8
5	Feed to Drum Filters if Thickener Underflow is fed to Filter Feed Tank	
	Slurry flow rate, gpm	288
	Solids rate, lb/hr	91,124
	Solids rate, ton/hr	45.6
	Total mass flow rate, lb/hr	199,099
	Percent solids, %	45.8

IPSC - MATERIAL BALANCE CALCULATIONS - HYDROCLONE-ENHANCED DEWATERING PROCESS - 2007

Scrubber Design Basis/Assumptions

- 800 t/hr Coal combined for two generating units
- 1 % **Maximum & Design** sulfur in the coal
- 0.6 **Normal** % sulfur in coal
- 0.45 **Minimum** % sulfur in coal
- 0.95 Fraction SO₂ removed
- 0.95 Fraction maximum oxidation of absorbed SO₂ for combined scrubber effluent
- 0.82 Fraction **Design** oxidation rate of absorbed SO₂
- 100 % load on both boilers for maximum solids production rate
- 100 % load on **one unit for minimum** solids production rate
- 15 % suspended solids in scrubber effluent to dewatering
- 0 ash solids in scrubber solids
- 5 % of limestone remains unreacted in filter cake (inerts plus unreacted CaCO₃)

Calculations - Maximum Solids Loading Conditions at 1% sulfur coal, both Units at full load, 95% oxidation rate

- 15.2 tons/hr SO₂ removal
- 38.8 t/hr gypsum produced at maximum sulfur 100% load
- 1.4 t/hr calcium sulfite produced at max sulfur 100% load
- 1.2 t/hr limestone solids in solids from scrubbers
- 41.4 t/hr total solids from scrubbers to dewatering

Calculations - Design Solids Loading Conditions at 1% sulfur coal, both units at full load, 82% oxidation rate

- 15.2 tons/hr SO₂ removal
- 33.5 t/hr gypsum produced
- 5.1 t/hr calcium sulfite produced at design conditions
- 1.2 t/hr limestone solids in solids from scrubbers
- 39.8 t/hr total solids from scrubbers to dewatering

Calculations - Normal Solids Loading Conditions at 0.6% sulfur coal, both units at full load, 95% oxidation rate

- 9.1 t/hr SO₂ removal
- 23.3 t/hr gypsum produced
- 0.9 t/hr calcium sulfite produced at design conditions
- 0.7 t/hr limestone solids in solids from scrubbers
- 24.9 t/hr total solids from scrubbers to dewatering

Calculations - Minimum Solids Loading Conditions at 0.45% sulfur coal, one unit at full load, 82% oxidation rate

- 3.4 t/hr SO₂ removal
- 7.5 t/hr gypsum produced
- 1.2 t/hr calcium sulfite produced
- 0.3 t/hr limestone solids
- 9.0 t/hr total solids from scrubbers to dewatering

Process Flow Calculations for Design, Normal and Minimum conditions

<u>Slurry from Scrubbers to Hydroclone Feed Tank</u>	<u>Design</u>	<u>Normal</u>	<u>Minimum</u>
Flow Rate From Scrubbers to Hydroclone Feed Tank, gpm	960	599	216
Solids Rate to hydroclone feed tank, lb/hr	79,629	49,704	17,917
Percent solids in slurry to hydroclone feed tank, %	15	15	15
<u>Slurry to Hydroclones</u>			
Flow rate to hydroclones, gpm	960	599	216
Percent solids in hydroclone feed, %	15	15	15
<u>Slurry in Hydroclone Overflow To Thickener</u>			
Flow rate in hydroclone overflow, gpm	817	519	184
Percent solids in hydroclone overflow, %	4.8	4.8	4.8
Solids rate in hydroclone overflow, lb/hr	20,519	12,808	4,617
<u>Slurry in Hydroclone Underflow to Hydroclone Underflow Tank</u>			
Flow rate in hydroclone underflow, gpm	143	80	32
Percent solids in hydroclone underflow, %	56	60	56
Solids rate in hydroclone underflow, lb/hr	59,110	36,896	13,300
<u>Hydroclone Underflow Tank to Filters @ 12 hr/day Filter Operation</u>			
Flow rate, gpm	285	161	64
Percent solids, %	56	60	56
Solids rate, lb/hr	118,220	73,792	26,599
Hydroclone U'flow Inventory surge during 12-hr/day filter downtime	102,688	57,868	23,105
Hydroclone tank capacities at 15-ft height differential, gal	107,894	107,894	107,894
Minimum Hours/day of filter operation required, hours/day	11.4	6.4	2.6
<u>Vacuum Filter Operation Calculations - 12-ft dia by 18-ft filter = 678 sq.ft.</u>			
Req'd filtration rate for 12-hr/day operation, lb/hr/ft ²	174	109	39
Filter Cake Moisture content Estimate at filtration rate, wt. %	17	14	11
Wet Cake production rate, ton/hr	71	43	15
Water in cake, gpm	0	0	0
Filtrate, gpm	285	161	64
<u>Fines Thickener Operating Calculations - Using one 60-ft. diameter thickener</u>			
Calculated Thickener Unit Area, ft ² /t/d	11	18	51
Design (operating) underflow concentration with polymer, wt. % ss	30	30	30
Estimated Maximum pumpable solids conc., wt. % ss	45	45	45
Minimum operating underflow conc., wt. % ss	15	15	15
Continuous underflow pumping rate at design U'flow conc., gpm	112	70	25
Overflow rate at design underflow concentrations, gpm	705	449	159
Hours sludge storage in thickener bed/ ft. of sludge at design, Hours	3	5	14

**IPSC
Sludge Scrubber Study
Job #10062**

BASIS OF ESTIMATE

Clarifications and Assumptions:

- ROM estimate +100%/- 50%.
- 40% contingency included.
- Overhead for labor unit rates are included in the final add-ons. Profit is built into the \$65/hr rate used for the estimate.
- Equipment demolition, new equipment installation and pricing was included per the job equipment list Rev C.
- ¼" thk natural rubber lining was estimated for all piping except the fiberglass sludge, water and air lines.
- Knife gates were estimated in all process lines.
- Pipe and steel painting was estimated as two coat epoxy over SP-6 blast cleaning.
- All cable is estimated as Teck90. Cable tray and conduit is galvanized.
- Heat trace and insulation of piping is not included.
- Labor value is based on work performed during a 50 hour week. Estimate is based on approximately 47,000 man-hours which include indirect man-hours.
- Per Diem was included at \$8.40 per hour for craft labor.
- Labor rate of \$65 per hour for all craft was used in this estimate and include burden, allowances for small tools, consumables, profit, etc.
- No radiography of pipe butt welds is included in the price. Estimate is based on visual weld exam only for steel piping.
- One hundred percent of the crew will be drug tested and go thru site specific training.
- This estimate includes allowances for electrical, instrumentation and piping demolition using composite rates for labor and materials.

Exclusions:

- Bonds, fees and permits.
- Builder's Risk Insurance.
- Allowance for external winter work.
- Remediation of toxic materials if encountered.
- Purchasing and expediting.

Pricing:

Current Material Quotes

- None
- Concrete price used: \$135/yd including additives

Recent Quotes on Similar Projects

- Carbon steel piping materials and valves
- Instrumentation

Factored Historical Pricing

- Electrical lighting and grounding

Schedule:

A construction schedule of ***6 months*** is anticipated.



ENGINEERING STUDY REPORT

JOB NO: 10062

SLUDGE CONDITIONING CAPACITY STUDY PROJECT

INTERMOUNTAIN POWER SERVICE CORPORATION

DELTA, UTAH

PREPARED BY:	G. BIGHAM	DISCIPLINE:	MECHANICAL	DATE:	8/4/10
PRIME REVIEW BY:	A. TWITCHELL	DISCIPLINE:	PROCESS	DATE:	8/4/10
TECH.REVIEW BY:	E. SUMMERS	DISCIPLINE:	CIVIL/STRUCTURAL	DATE:	
TECH.REVIEW BY:	I. KENISON	DISCIPLINE:	ELECTRICAL	DATE:	
TECH.REVIEW BY:		DISCIPLINE:		DATE:	
TECH.REVIEW BY:		DISCIPLINE:		DATE:	
TECH.REVIEW BY:		DISCIPLINE:		DATE:	
PROJ ENGR. APPROV. BY:		TITLE:		DATE:	
PROJ MGM. APPROV. BY:	D. BURNINGHAM	TITLE:	PROJECT MANAGER	DATE:	
CLIENT APPROVAL BY:				DATE:	
REVISION DESCRIPTION	SECT. OR PAGES	REV BY	APP BY	REV NO.	DATE
FOR REVIEW BY IPSC	ALL	A			8/3/10

IP12_004862

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SPECIFICATION FOR
CAPACITY INCREASE STUDY

Project: 10062

REV. A

8/3/10

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1.0 EXECUTIVE SUMMARY

Intermountain Power Service Corporation) IPSC hired FLSmidth to prepare a plus 100% minus 50% cost estimate for engineering, procurement, and construction of capacity and performance upgrades to the Sludge Dewatering System at the Intermountain Generating Station. IPSC provided the scope of work, design criteria, and reference drawings, equipment information and a previous study which FLSmidth based the project on. Representatives of FLSmidth met with representatives of IPSC at the power plant on July 14, 2010 to kick-off the project with a due date of July 30, 2010. The due date was later extended to August 4, 2010.

FLSmidth developed three promising options to meet the scope of work and selected the option that best meet the requirements of the scope of work (Option 1). The modifications associated with Option 1 include installation of oxidation equipment for the scrubber blowdown, new horizontal belt filters to replace the existing drum filters, addition of a storage tank for thickener underflow, and miscellaneous pumps, piping, structural modifications and electrical equipment to support the modified process. Then FLSmidth performed preliminary design engineering, developed equipment and materials lists, and obtained budgetary quotations for the equipment and materials. The estimates and a more detailed discussion of the project are included in this report.

The project duration was too short to adequately determine equipment numbers and sizes. FLSmidth recommends performing testing, equipment sizing and re-estimating Option 1 and also finishing the evaluation of Options 2 and 3 before finalizing plans for upgrading the Sludge Conditioning System.

2.0 INTRODUCTION

IPSC contracted FLSmidth to study options for increasing the capacity of their scrubber sludge dewatering system to meet the future need to burn coal with higher levels of sulfur. The goal of this study is to provide an estimate for detailed engineering, equipment purchase costs, and installation costs to upgrade the sludge conditioning system to dewater the scrubber reaction tank blowdown liquid so that only a clear liquid will be sent to the Waste Water Holding Basin. IPSC provided data regarding the capacity of their existing system, plant drawings, equipment sizes and rating information, a previous study done by Codan Development (Jim Wilhelm), and a material balance spreadsheet developed to model scrubber system operating modes. IPSC also provided the data necessary for the basis of the study including sulfur level in the coal, flow rate of scrubber sludge blowdown from the reaction tanks, oxidation level of the scrubber sludge and particle size distributions for sludge entering and leaving the

Hydrocyclone cluster. FLSmidth personnel (Jerry Hunt, Alvin Twitchell, and Gordon Bigham) traveled to IPSC for a kick-off meeting and walk-through of the facilities involved in the project on July 14, 2010.

3.0 SCOPE OF WORK

3.1 Goal:

- 3.1.1 FLSmidth will recommend plant modifications needed to separate the solids from the water in Units 1 and 2 scrubber sludge based upon quantities, particle size distributions, and constituents provided by IPSC.
- 3.1.2 FLSmidth will supply a capital cost estimate for equipment, demolition, installation, structural modifications, and engineering within the limits of plus 100% and minus 50% by August 4, 2010.
- 3.1.3 FLSmidth will provide additional services to refine this estimate after August 4, 2010 per instructions from IPSC, with total cost for the entire project not to exceed the original Purchase Order amount.

3.2 Project Boundary Limits

- 3.2.1 Scrubber Sump Pumps in Units 1 and 2 are a boundary
- 3.2.2 Loading Zones of conveyors leaving Sludge Conditioning are a boundary
- 3.2.3 The chutes below the Ash Silo Rotary Vane valves are a boundary
- 3.2.4 Thickener overflow lines are a boundary
- 3.2.5 Polymer feed system insertion points are a boundary
- 3.2.6 Power and utility feeds to the area are boundaries.

3.3 Major Equipment Included in Scope Evaluation

- 3.3.1 Hydrocyclone feed pumps
- 3.3.2 Hydrocyclones
- 3.3.3 Thickeners
- 3.3.4 Thickener Underflow Pumps
- 3.3.5 Vacuum Filters and their auxiliary equipment

- 3.3.6 Filter Feed Pumps
- 3.3.7 Filter discharge conveyors
- 3.3.8 Pug Mills
- 3.3.9 Piping between equipment
- 3.3.10 Scrubber Sump Pumps
- 3.3.11 Electrical Substation
- 3.3.12 Electrical Motor Control Centers
- 3.4 Process Scope
 - 3.4.1 Process Flow Sketch
 - 3.4.2 Estimate of Flows
 - 3.4.3 Equipment type & size recommendations
- 3.5 Mechanical Scope
 - 3.5.1 Equipment List with pricing
 - 3.5.2 Hand mark-ups of existing GA's
 - 3.5.3 Piping material take-off & cost estimate
 - 3.5.4 Demolition & Construction Estimate
- 3.6 Structural Scope
 - 3.6.1 Hand mark-up of existing GA's
 - 3.6.2 Material Take-off
 - 3.6.3 Demolition & Construction Estimate
- 3.7 Electrical Scope
 - 3.7.1 Cursory evaluation of electrical capacity available for changes in system
 - 3.7.2 Cost Estimate: Capital, demolition and installation
- 3.8 Constraints
 - 3.8.1 Eliminate solids overflowing the thickeners under normal operating and weather conditions
 - 3.8.2 Eliminate bypassing of sludge directly to the waste water holding pond

- 3.8.3 Remove solids from water and send to existing discharge conveyors
- 3.8.4 No modifications to existing ash silos and rotary vane valves
- 3.8.5 Limit filter operation to 12 hours per day if practical
- 3.8.6 Change cyclone operation from on/off to variable flow.

4.0 OPTION DESCRIPTION

FLSmidth personnel from various departments worked together to generate options for meeting the goals for the project. As a result of this effort three distinct options were developed.

- 4.1 Option 1 (Recommended by FLSmidth): Install an Oxidation system for sludge leaving the scrubbers, 2 small horizontal belt filters to replace the drum filters, and a second filter feed tank (see process flow diagram Option 1).
 - 4.1.1 Install three 270 m³, FLSmidth Oxallizer tanks near Sludge Transfer to convert the Calcium Sulfite in the sludge into Calcium Sulfate for easier processing. The tanks would be installed outside on concrete foundations with a common containment wall.
 - 4.1.2 Install two small horizontal belt filters (250 ft² filter area) on the third floor of the Sludge Conditioning Building, both discharging directly above the west pug mill feed conveyor.
 - 4.1.3 Belt filter auxiliary equipment would be installed on the ground floor.
 - a) Two new 250 HP vacuum pumps with receivers are included to replace the existing.
 - b) Two new filter cloth wash skids are included.
 - c) Two new cake wash skids are included
 - d) Install new seal and lubricating water piping from service water system.
 - 4.1.4 The existing drum filters would be demolished and conveyors installed on the filter floor to transfer the belt filter discharge to either pug mill for continued processing.

- a) One new filter discharge shuttle conveyor will be installed above the filter floor to receive the cake discharge from both belt filters. The shuttle conveyor can either discharge to the existing west pug mill feed conveyor or to a new transfer conveyor to feed the east pug mill.
 - b) One new stationary transfer conveyor to receive filter cake from the new shuttle conveyor and transfer it to the existing east pug mill feed conveyor.
- 4.1.5 Install a new surge tank, similar in size to the filter feed tank, to hold the thickener underflow. This will provide enough storage to allow 14 hours filter down time. The contents will be pumped to the Filter Feed Tank during filter operation. This tank will be installed outside in a common containment with Oxallizers.
- 4.1.6 New Krebs SlurryMAX cyclone feed pumps with variable frequency drives to control level in the Thickener Feed & Mix Tank.
- 4.1.7 New Filter Feed pumps for increased head and capacity requirements.
- 4.1.8 Relocate the existing cyclone feed pumps to the Oxallizer system to pump oxidized sludge to the Thickener Feed & Mix Tank.
- 4.1.9 Relocate the existing Filter Feed Pumps to the new Thickener Underflow Storage Tank to pump back to the Filter Feed Tank.
- 4.1.10 Replace the Filtrate Sump Pumps to handle the additional flow.
- 4.1.11 Replace the Scrubber Drain Sump Pumps with vertical cantilevered sump pumps with extended suction lines. The pumps will be mounted at floor level to prevent flooding of the bearings and motors.
- 4.1.12 Replace the following piping:
- a) Replace the 5" rubber lined piping from the scrubber sumps to Sludge Transfer, with Ershigs 6" abrasion resistant FRP piping.
 - b) Replace Thickener underflow piping with Ershigs FRP piping and extend past the Filter Feed Tank to the new Underflow Storage Tank.

- c) Replace vacuum piping with larger piping per manufacturer's recommendation.
- d) Replace Filtrate piping with larger pipe for more flow.
- e) Replace pipe spools by Cyclone Feed Pumps to reconnect to existing piping.

4.2 Option 2: Replace existing drum filters with horizontal belt filters and install another filter feed tank (see process flow diagram Option 2).

4.2.1 The third floor in the Sludge Conditioning building would be constructed to hold two 750 ft² horizontal belt filters.

4.2.2 Belt Filter auxiliary equipment would be installed on the ground floor.

- a) Two new 500 HP vacuum pumps with receivers are included to replace the existing.
- b) Two new filter cloth wash skids are included.
- c) Two new cake wash skids are included
- d) Install new seal and lubricating water piping from service water system.

4.2.3 The existing drum filters would be demolished and conveyors installed on the filter floor to transfer the belt filter discharge to either pug mill for continued processing.

- a) Two new filter discharge shuttle conveyors will be installed above the filter floor; one to receive the cake discharge from each belt filter. Each shuttle conveyor can either move out of the way and allow filter cake to fall onto the existing west pug mill feed conveyor or catch the cake and move it to a new transfer conveyor to feed the east pug mill.
- b) One new stationary transfer conveyor to receive filter cake from the new shuttle conveyors and transfer it to the existing east pug mill feed conveyor.

4.2.4 Install a new surge tank, similar in size to the filter feed tank, to hold the thickener underflow. This will provide enough storage to allow 14 hours filter down time. The contents will be pumped to the Filter Feed Tank during filter operation. This tank will be

installed outside the Sludge Transfer Building on a concrete foundation and containment wall.

- 4.2.5 New Krebs SlurryMAX cyclone feed pumps with variable frequency drives to control level in the Thickener Feed & Mix Tank.
- 4.2.6 New Filter Feed pumps for increased head and capacity requirements.
- 4.2.7 Relocate the existing Filter Feed Pumps to the new Thickener Underflow Storage Tank to pump back to the Filter Feed Tank.
- 4.2.8 Replace the Filtrate Sump Pumps to handle the additional flow.
- 4.2.9 Replace the Scrubber Drain Sump Pumps with vertical cantilevered sump pumps with extended suction lines. The pumps will be mounted at floor level to prevent flooding of the bearings and motors.
- 4.2.10 Replace the following piping:
 - a) Replace the 5" rubber lined piping from the scrubber sumps to Sludge Transfer, with Ershigs 6" abrasion resistant FRP piping.
 - b) Replace Thickener underflow piping with Ershigs FRP piping and extend past the Filter Feed Tank to the new Underflow Storage Tank.
 - c) Replace vacuum piping with sizes recommended by filter manufacturer.
 - d) Replace Filtrate piping with larger pipe for more flow.
 - e) Replace pipe spools by Cyclone Feed Pumps to reconnect to existing piping.

- 4.3 Option 3: Install a Horizontal, Plate & Frame Filter Press and a thickener underflow storage tank (see process flow diagram Option 3).

- 4.3.1 Install a horizontal plate and frame filter press to receive and dewater thickener underflow in a separate stream.
- 4.3.2 Install a new surge tank, similar in size to the filter feed tank, to hold the thickener underflow. This will provide enough storage to allow 18 hours of thickener underflow storage. The contents

will be pumped to the Filter Press for processing separately from the cyclone underflow. This tank will be installed outside the Sludge Transfer Building on a concrete foundation and containment wall.

- 4.3.3 Install a surge bin with a feeder at the discharge of the filter press to collect each batch and feed it to a conveyor at a uniform rate.
- 4.3.4 Install conveyors to take filter cake directly to both pug mills.
- 4.3.5 New Krebs SlurryMAX cyclone feed pumps with variable frequency drives to control level in the Thickener Feed & Mix Tank.
- 4.3.6 New Filter Feed pumps for increased head and capacity requirements.
- 4.3.7 Relocate the existing Filter Feed Pumps to the new Thickener Underflow Storage Tank to pump back to the new Filter Press.
- 4.3.8 Replace the Filtrate Sump Pumps to handle the additional flow.
- 4.3.9 Replace the Scrubber Drain Sump Pumps with vertical cantilevered sump pumps with extended suction lines. The pumps will be mounted at floor level to prevent flooding of the bearings and motors.
- 4.3.10 Replace the following piping:
 - a) Replace the 5" rubber lined piping from the scrubber sumps to Sludge Transfer, with Ershigs 6" abrasion resistant FRP piping.
 - b) Replace Thickener underflow piping with Ershigs FRP piping and extend past the Filter Feed Tank to the new Underflow Storage Tank.
 - c) Replace vacuum piping with 12 inch and 14 inch piping as require for additional flow
 - d) Replace Filtrate piping with larger pipe for more flow.
 - e) Replace pipe spools by Cyclone Feed Pumps to reconnect to existing piping.

5.0 OPTION 1 EVALUATION

5.1 Advantages:

- 5.1.1 This is the only option that guarantees acceptable thickener performance since most of the Sulfite fines will be converted to Sulfates and the heavy particles will be removed in the cyclones. So this is the only option that meets the goal stated in the scope of work section to prevent solids from flowing into the Waste Water Holding Basin. Therefore this is the FLSmidth recommended option.
- 5.1.2 Small filters fit nicely into the 3rd floor of the Sludge Conditioning Building.
- 5.1.3 Belt filters tend to be more reliable than drum filters.
- 5.1.4 Belt filters are more tolerant of variations in sludge consistency.
- 5.1.5 The Oxidation equipment allows more flexibility for scrubber operation since pH excursions and air sparging problems in the reaction tanks can be compensated for by oxidation system.
- 5.1.6 Existing Crane ways to the ground floor is maintained.
- 5.1.7 Existing stairway access is maintained.
- 5.1.8 The additional conveyors allow use of either belt filter in combination with either pug mill, which effectively increases equipment redundancy and availability.
- 5.1.9 This options may produce marketable gypsum that could be sold as a byproduct like fly ash.

5.2 Disadvantages:

- 5.2.1 The tanks selected for this project are mechanically aspirated. The oxidation system requires lots of power regardless of whether it is mechanically or pneumatically aspirated.
- 5.2.2 The Oxallizer tanks are additional equipment to operate and maintain.
- 5.2.3 Bridge crane access to the filter floor is lost due to the location of the filters. Some removable panels could be installed as well as monorails to assist in demolition of the existing drum filters and maintenance of the conveyors.

- 5.2.4 Most of the construction can be done with the existing sludge system in service. However, there will be some sludge system outage time required to switchover and start-up the new system. A detailed analysis of the constructability of this option will be required to quantify the actual down time required.

6.0 OPTION 2 EVALUATION

6.1 Advantages:

- 6.1.1 Belt filters tend to be more reliable than drum filters.
- 6.1.2 Belt filters are more tolerant of variations in sludge consistency. Vacuum can be regulated to give consistent cake properties with varying amounts of sulfites in the mix.
- 6.1.3 The additional conveyors allow use of either belt filter in combination with either pug mill, which effectively increases equipment redundancy and availability.
- 6.1.4 The only additional equipment to operate are the belt filter auxiliaries (belt wash, cake wash, sealing and lubrication systems).

6.2 Disadvantages:

- 6.2.1 Bridge crane access to the filter floor is lost due to the location of the filters. Some removable panels could be installed as well as monorails to assist in demolition of the existing drum filters and maintenance of the conveyors.
- 6.2.2 Extensive modifications will be required to fit the larger filters into the third floor. The filters will block the existing crane way and the two stairways on the West side of the third floor. So, a building extension for crane and stairs or an external stair tower with wall penetrations for monorail cranes may be necessary on both the second and third floors.
- 6.2.3 Maintenance access will be crowded due to the width of the filters and the floor area available.
- 6.2.4 The consistency of the filter feed will change throughout the shift due to the segregation of the heavy material in the Filter Feed Tank and the light (or fine) material in the Thickener Underflow Storage tank. Our proposal makes no provision for mixing and homogenizing the material prior to filter operation. At the start of

filter operation the mixture will be mostly Sulfate and will dewater quickly. So, the cake will tend to be dry. As the contents of the Thickener Underflow Tank are pumped into the Filter Feed Tank, the mixture will gain a larger and larger percentage of Sulfites that will tend to slow the dewatering process. So the cake will become wetter. It will be more difficult for the operators to maintain filter cake consistency to and from the pug mills as the mixture changes.

- 6.2.5 This option does not improve thickener operation. The fine particles will still tend to float and overflow the thickener weirs.
- 6.2.6 As with Option 1, most of the construction can be done with the existing sludge system in service. However, there will be some sludge system outage time required to switchover and start-up the new system. A detailed analysis of the constructability of this option will be required to quantify the actual down time required.

7.0 OPTION 3 EVALUATION

7.1 Advantages:

- 7.1.1 This option requires little or no down time for switch-over and start-up of the new equipment. Since the new sulfite handling equipment would be separate from the filtration system, the equipment can be constructed without interfering with the existing system.
- 7.1.2 Filter presses are tolerant of wide variations in solids content of the incoming fluid. So the thickener bed density is not as critical to filter press performance. This characteristic allows IPSC to stop recirculating the thickener underflow back into the feed well.

7.2 Disadvantages:

- 7.2.1 There will be two separate processing systems with different characteristics feeding the pug mills.
- 7.2.2 The two systems would not operate simultaneously. So operators might need to operate the drum filters and the filter press twice in a shift to keep enough head room in the tanks for 12 to 16 hours of down time.

- 7.2.3 The filter press is a batch system. So, a surge bin with a feeder is needed to deliver constant flow to the pug mill. This process tends to need more operator oversight to keep from plugging.
- 7.2.4 While this option eliminates thickener recirculation, it may not fix the problem with the thickener bed. The fine particles will still tend to float and overflow the thickener weirs.

8.0 LIMITATIONS OF THIS STUDY

Due to the short schedule for this project, the three options were not evaluated fully. In fact the pug mills and the size of the scrubber drain sumps have been neglected completely due to the complexities in working out the main process issues. Therefore, there are parts of the three options that are insufficiently complete to make informed decisions and should be studied more completely before accepting or rejecting the option for installation. In this section, we will note the limitations of each option evaluation for future reference.

One weakness that applies generally to all the options in this study is the lack of testing. Due to the short schedule we were unable to perform the testing necessary for good equipment sizing. Our time was used to develop and define options based upon testing and recommendations made previously and including the operating results of the Hydrocyclone installation. Because of this, our sizing estimates are probably somewhat more conservative than necessary. This impacts the estimate in two ways. First, the equipment is probably oversized which leads to a cost estimate with a higher price than necessary. Second, the space requirement for new equipment is probably larger than really needed.

Once IPSC personnel have time to evaluate the results of this study, we recommend that sample testing be done as needed to size the equipment properly, that a refined estimate be performed and the options ranked for selection of the best overall.

8.1 Option 1:

- 8.1.1 This option received the recommendation of FLSmidth because it is the only option that, with the limited information we have, successfully meets the goals. It greatly reduces the amounts of sulfites handled by the system which in turn unloads the thickeners allowing them to settle and greatly reduces the size of the belt filters (only about 1/3 the filtration area is required for oxidized sludge based upon initial estimates). However, we recommend lab testing of fully oxidized sludge for filter area sizing to make sure we have sized the filters correctly. We also

recommend testing to size the oxidation equipment. There is a good chance that we can use two tanks instead of three.

8.2 Option 2:

8.2.1 While we believe this to be the favorite option of employees at IPSC, we were not able to complete the evaluation due to our estimate of required filter area for the horizontal belt filters. The Sulfites in the sludge led FLSmidth to estimate that 750 ft² of active filter area is required. We looked at 6.5, 4.2 and 3.0 and 2.0 meter wide filters. We determined that the larger two were too wide to fit in the existing building and that the 2.0 meter filter would require a long addition to the east side of the building. So, the 3.0 meter filter seemed like our best option. With some work, it appeared that we would be able to fit two 3.0 meter wide filters into the building. But we ran into problems fitting the conveyors to handle the filter discharge and move it to the pug mills. Given more time we can finish evaluation of the 2 and 3 meter horizontal belt filter options. At this point, we recommend testing samples and resizing the filters before proceeding. If filter area can be reduced, it will greatly reduce the cost of this option.

8.3 Option 3:

8.3.1 This option appears to have the least impact during construction and start-up, but we spent the least time looking at this option. So it has, by far, the most uncertainty associated with it. We have not sized a filter press, nor have we tried to locate it in the plant. It is possible that it would fit on the third floor of Sludge Conditioning. Initially it was assumed to be in a new building east of sludge conditioning where a conveyor would take the filter cake through east wall of Sludge Conditioning and directly to the pug mills. We recommend testing thickener underflow to size and price a horizontal filter press. We also recommend evaluation of methods to deliver the filter cake to the pug mills so that this option can be evaluated equally against the others.

9.0 LOW PRIORITY ITEMS

9.1 A number of low priority items were included in the original scope of work to be addressed as time permitted. A few of these items were addressed as it was convenient while working on the associated equipment.

9.1.1 Scrubber Drain Sump Pumps: We have included in our estimates eight Galigher vertical sump pumps with suction extensions. These pumps are typical of pumps for this application and would be mounted at floor level to eliminate flooding of bearings and motor. The pumps are listed in paragraphs 4.1.11, 4.2.9 and 4.3.9 and in the estimate.

9.1.2 Alternatives to Rubber Lined Steel Piping: While quoting rubber lined pipe for the estimate we also contacted Ershigs for a quote on abrasion resistant Fiberglass Reinforced Plastic (FRP) piping. Ershigs is recognized as a manufacturer of high quality abrasion resistant FRP slurry piping. They provided a quote that was less expensive than our quote for rubber lined steel piping. The quote included 40 foot flanged spools with expansion joints for this application. It appears that FRP is an attractive replacement for rubber lined steel. We believe FRP piping could be used for most of the piping in this project, but we only quoted 6" piping at this time.

9.1.3 Thickener Upsets: As we have discussed Thickener bed upsets resulting in solids overflowing the weirs, we have the following recommendations:

- a) Reduce or eliminate underflow recirculation by replacing the damaged rubber lined thickener underflow piping to reduce the potential for plugging in the underflow system. Then reduce the flow rate while being careful to stay above 3 ft/s in the underflow lines.
- b) Route all sumps drain lines and the filtrate pumps to the Thickener Feed Tank, not the thickeners, and screen the flows to prevent rocks, bolts, gaskets, and other trash from entering the sludge system at the thickener feed tank.
- c) Maintain the screens on the scrubber drain sump lines at the Thickener Feed Tank to prevent trash from entering the sludge system.

- d) Contact FLSmidth (Eimco) personnel to get a recommendation for reorientation of the thickener feed lines to give the least turbulence in the bed.

9.1.4 Cyclone Apex Quote: While working with Krebs personnel on this project, we also obtained a recommendation and a quote for new apexes for the cyclones in the cluster in Sludge Transfer. They are designed for the higher flows IPSC has been using. Please see attached quote.

9.1.5 Cyclone Shut-off Valve Quote: While working with Krebs on this project, we obtained a recommendation and quotation for high quality shut-off valves for the cyclones in the cluster in Sludge Transfer. Please see attached quote.

10.0 CONCLUSIONS

- 10.1 Of the three options studied only Option 1 is certain to solve the problems of system capacity and solids separation. However, due to time restraints, a complete evaluation of the options was not possible and significant uncertainty remains regarding equipment sizing.
- 10.2 Options 2 and 3 are significant upgrades to the existing system, but do not completely address thickener bed settling problems. Marginal improvements to thickener operation can be made with relatively little expense by adopting the recommendations under paragraph 9.1.3 in addition to the flocculant modifications currently in progress.

11.0 RECOMMENDATIONS

- 11.1 FLSmidth recommends the following:
 - 11.1.1 Sampling and testing fully oxidized scrubber sludge for sizing of oxidation system and for small belt filters (Option 1).
 - 11.1.2 Sampling and testing 82% or lower oxidized scrubber sludge for sizing the large belt filter (Option 2).
 - 11.1.3 Sampling and testing thickener underflow for filter press sizing (Option 3).
 - 11.1.4 Design conveyor routing for Option 2
 - 11.1.5 Design equipment location and conveyor routing for Option 3

- 11.1.6 Redesign building crane access for Option 2
- 11.1.7 Redesign stair access for Option 2
- 11.1.8 Investigate Pug Mill optimization options for all Options.
- 11.1.9 Check Scrubber Drain Sump sizing
- 11.1.10 Revise Option 1 Estimate and complete Option 2 & 3 estimates.
- 11.1.11 Meet with IPSC to discuss and select best option.

12.0 APPENDIX A BASIS OF COST ESTMATE**12.1 Clarifications and Assumptions:**

- 12.1.1 ROM estimate +100%/- 50%.
- 12.1.2 40% contingency included.
- 12.1.3 Overhead for labor unit rates are included in the final add-ons. Profit is built into the \$65/hr rate used for the estimate.
- 12.1.4 Equipment demolition, new equipment installation and pricing was included per the job equipment list Rev C.
- 12.1.5 ¼" thk natural rubber lining was estimated for all piping except the fiberglass sludge, water and air lines.
- 12.1.6 Knife gates were estimated in all process lines. Pipe and steel painting was estimated as two coat epoxy over SP-6 blast cleaning.
- 12.1.7 All cable is estimated as Teck90. Cable tray and conduit is galvanized.
- 12.1.8 Heat trace and insulation of piping is not included.
- 12.1.9 Labor value is based on work performed during a 50 hour week. Estimate is based on approximately 47,000 man-hours which include indirect man-hours.
- 12.1.10 Per Diem was included at \$8.40 per hour for craft labor.
- 12.1.11 Labor rate of \$65 per hour for all craft was used in this estimate and include burden, allowances for small tools, consumables, profit, etc.
- 12.1.12 No radiography of pipe butt welds is included in the price. Estimate is based on visual weld exam only for steel piping.
- 12.1.13 One hundred percent of the crew will be drug tested and go thru site specific training.
- 12.1.14 This estimate includes allowances for electrical, instrumentation and piping demolition using composite rates for labor and materials.

12.2 Exclusions:

- 12.2.1 Bonds, fees and permits.
- 12.2.2 Builder's Risk Insurance.
- 12.2.3 Allowance for external winter work.
- 12.2.4 Remediation of toxic materials if encountered.
- 12.2.5 Purchasing and expediting.
- 12.3 Picing:
 - 12.3.1 Current Material Quotes
 - 12.3.2 None
 - 12.3.3 Concrete price used: \$135/yd including additives
- 12.4 Recent Quotes on Similar Projects
 - 12.4.1 Carbon steel piping materials and valves
 - 12.4.2 Instrumentation
- 12.5 Factored Historical Pricing
 - 12.5.1 Electrical lighting and grounding
- 12.6 Schedule:
 - 12.6.1 A construction schedule of **6 months** is anticipated.



SPECIFICATION FOR
CAPACITY INCREASE STUDY

Project: 10062
REV. A
8/3/10

13.0 APPENDIX B

PROJECT COST ESTIMATE



SPECIFICATION FOR
CAPACITY INCREASE STUDY

Project: 10062
REV. A
8/3/10

14.0 APPENDIX C

SIMPLIFIED PROCESS FLOW DIAGRAMS



SPECIFICATION FOR
CAPACITY INCREASE STUDY

Project: 10062
REV. A
8/3/10

15.0 APPENDIX D

EQUIPMENT LIST



SPECIFICATION FOR
CAPACITY INCREASE STUDY

Project: 10062

REV. A

8/3/10

16.0 APPENDIX E

RAWING MARKUPS

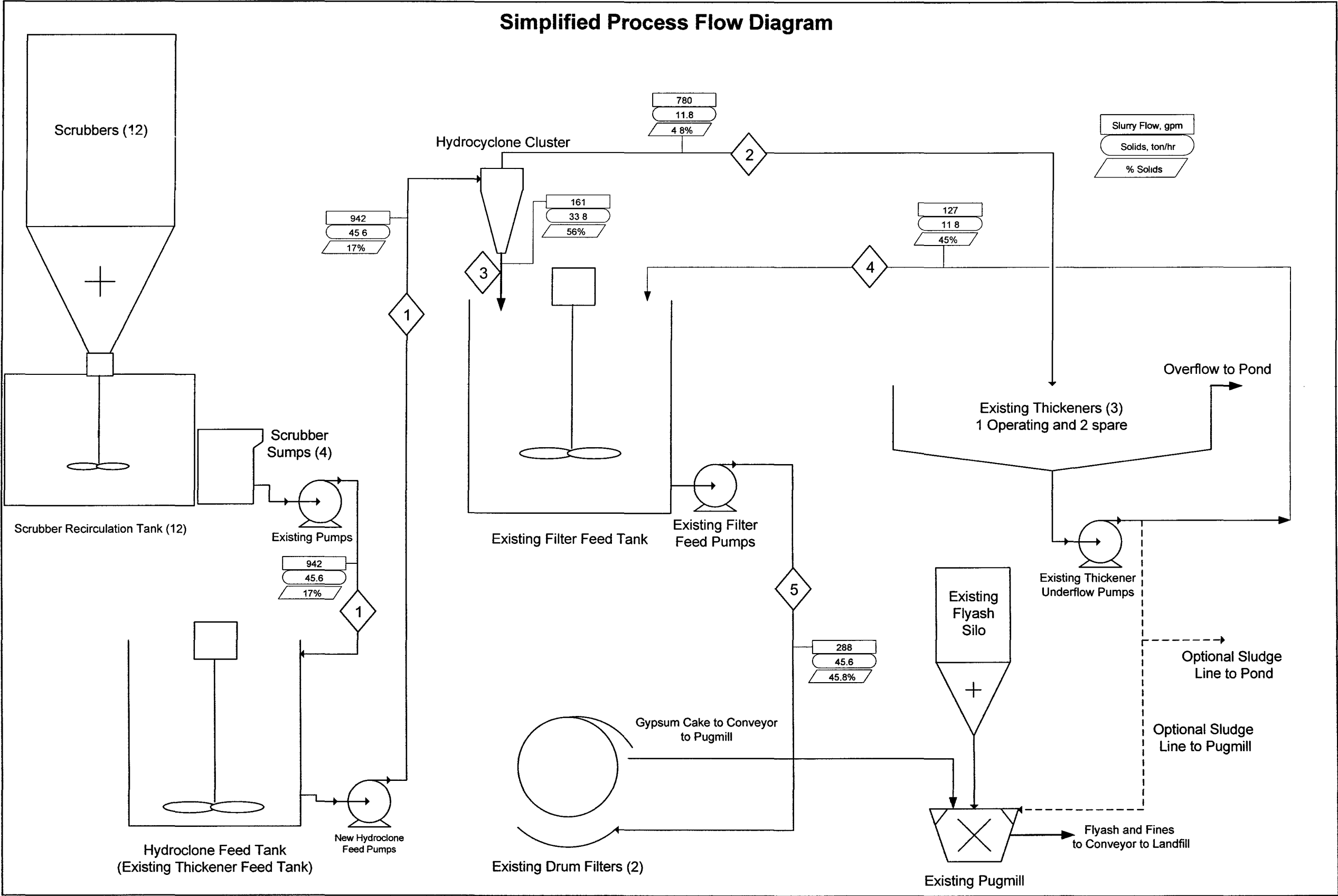


SPECIFICATION FOR
CAPACITY INCREASE STUDY

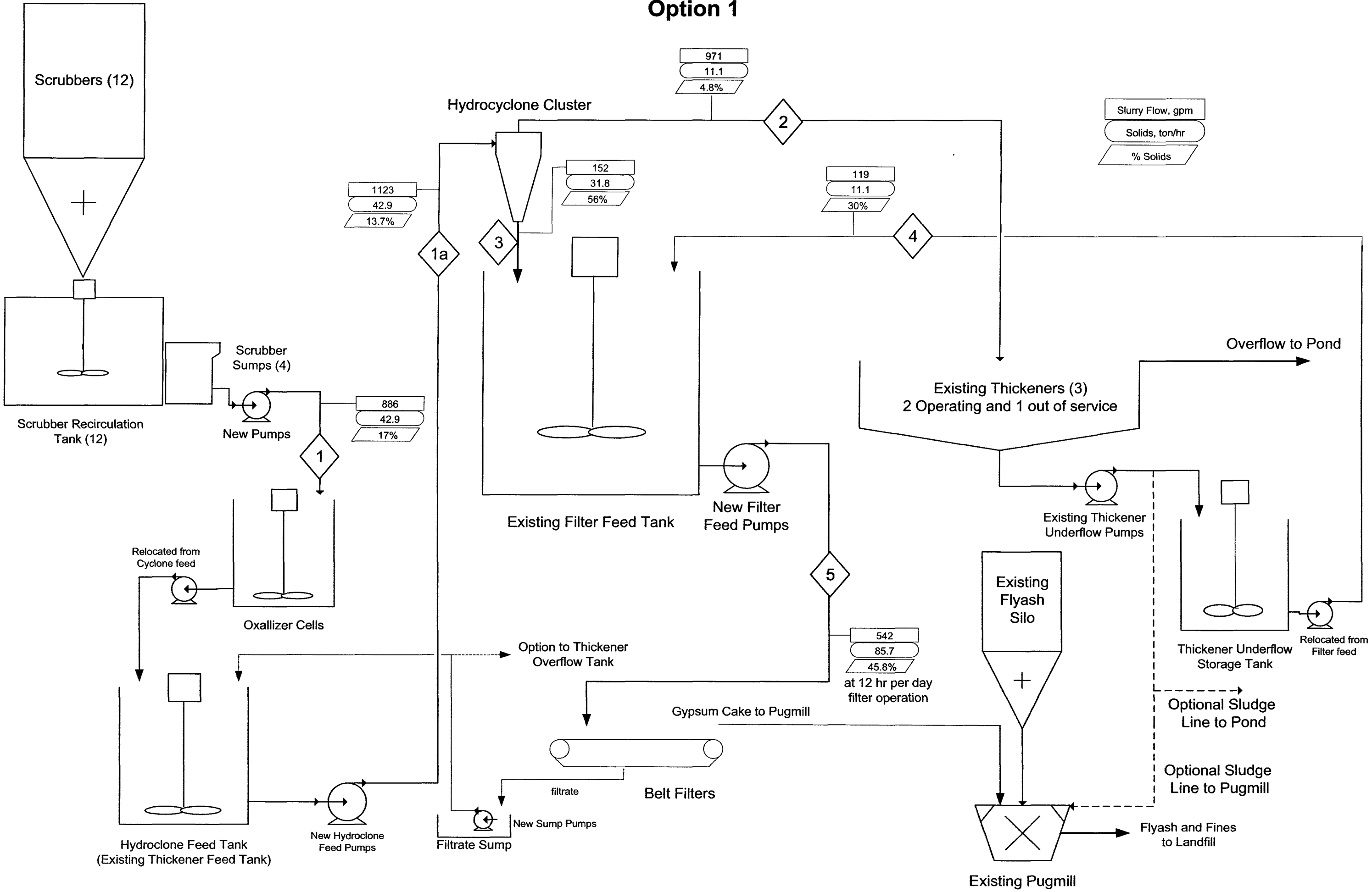
Project: 10062
REV. A
8/3/10

17.0 APPENDIX F

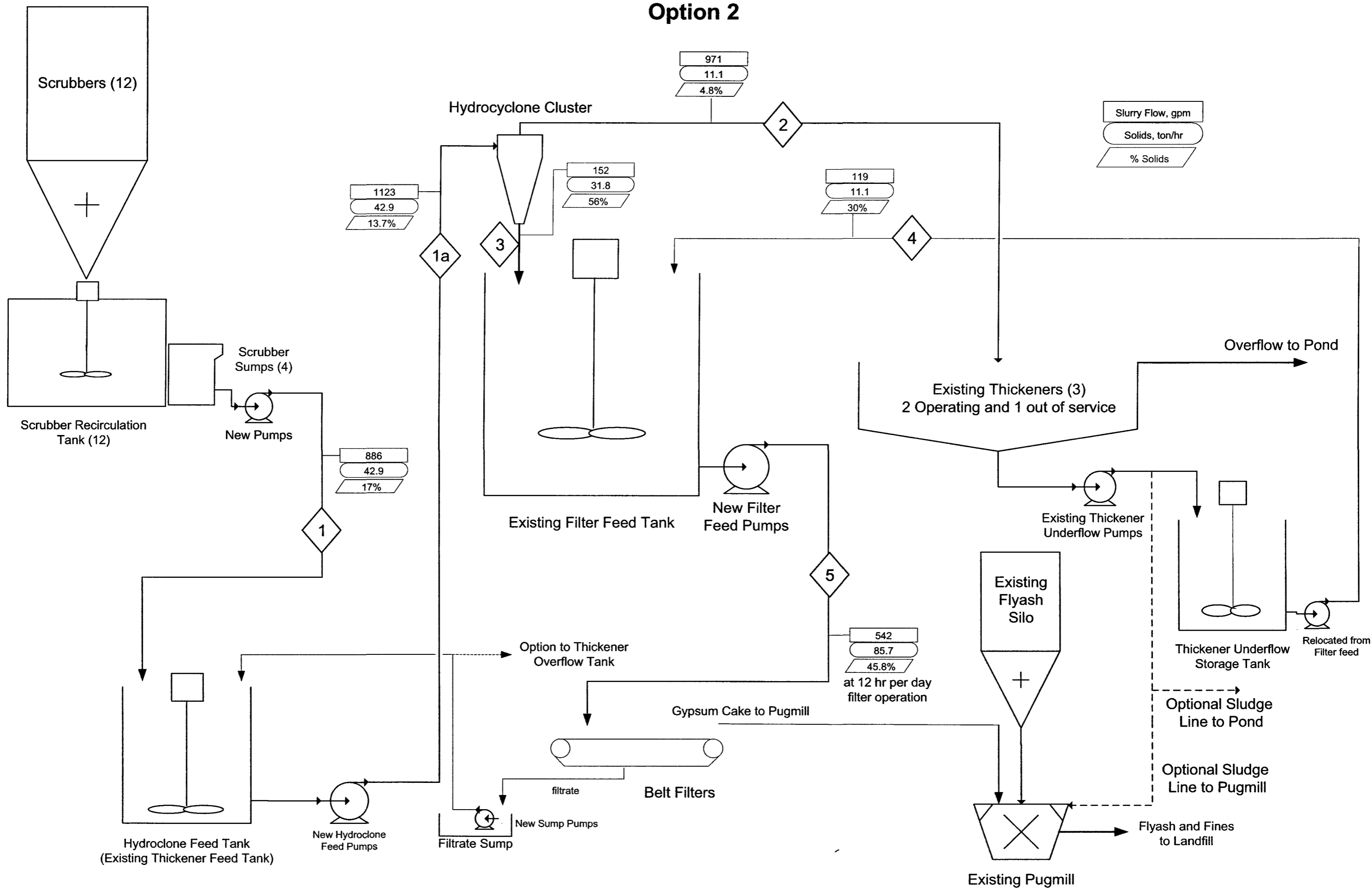
QUOTES FOR LOW PRIORITY EQUIPMENT



Simplified Process Flow Diagram
Option 1



Simplified Process Flow Diagram
Option 2



Simplified Process Flow Diagram
Option 3

Slurry Flow, gpm
Solids, ton/hr
% Solids

